Geomorphic assessments of New Hampshire's Rivers

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What is fluvial geomorphology?

Fluvial = action of running water

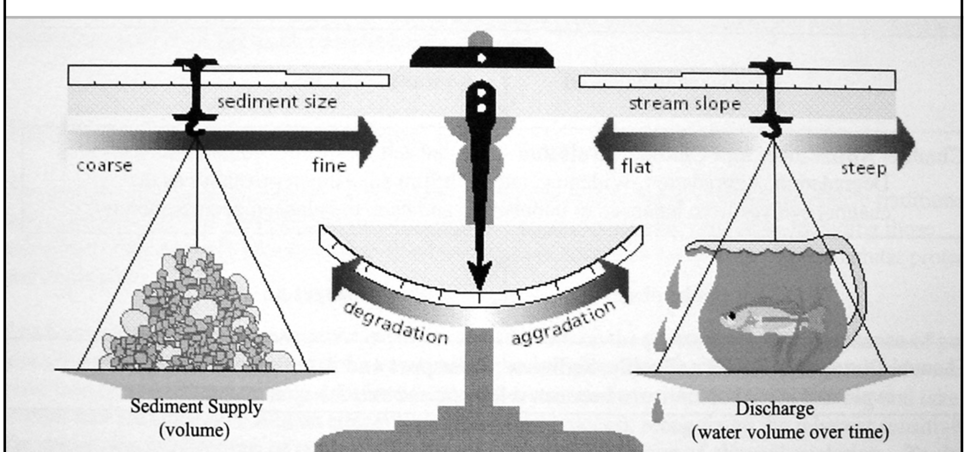
Geomorphology

Geo = Earth

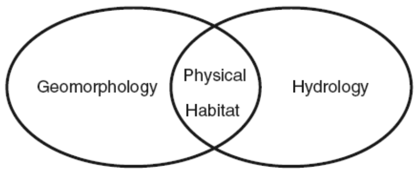
morph = form

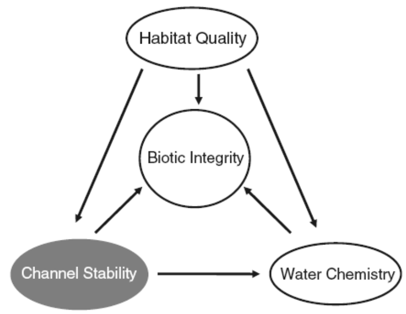
ology = study of

The study of how running water shapes the landforms on the Earth's surface


sediment size
coarse
fine
stream slope
flat
steep
degradation
aggradation
Sediment Supply
(volume)
Discharge
(water volume over time)

So, why do we care about all this river geomorphology stuff??!!





What are geomorphic assessments?

- Methods to evaluate the present condition of a river.
- **Are flow and sediment transport in balance?**
  - Excessive sedimentation
  - Excessive erosion
- **Is the river maintaining geomorphic integrity?**
- **If yes, increases the chances of good habitat for aquatic life.**

Vermont Stream Geomorphic Assessment
Phase 1 Handbook

WATERSHED ASSESSMENT

USING MAPS, EXISTING DATA, AND WINDSHIELD SURVEYS

Vermont Agency of Natural Resources
May, 2007

Vermont Stream Geomorphic Assessment
Phase 2 Handbook

RAPID STREAM ASSESSMENT

FIELD PROTOCOLS

Vermont Agency of Natural Resources
May, 2007

Geomorphic assessments so far in New Hampshire

2008
- Upper and Lower Exeter River watersheds

2009
- Ammonoosuc
- Middle Exeter watershed
- Isinglass

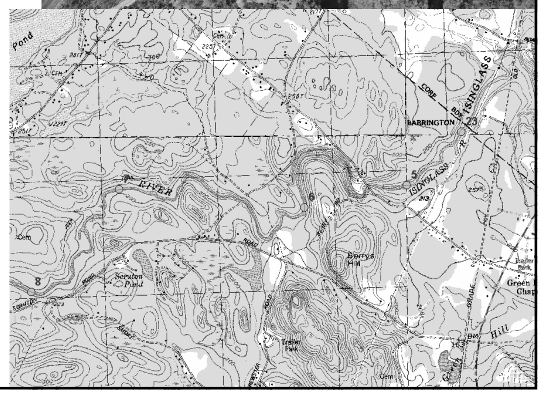
2010
- Cocheco and Lamprey watersheds

2011 and beyond
- Piscataquog
- Souhegan
- ?????

Phase 1

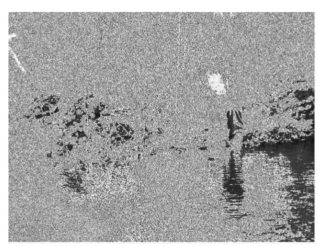
- Determination of reach breaks
  - Grade controls
  - Surficial and bedrock geology
  - Soils
  - Land cover/land use
  - Major tributaries
  - Changes in bed material characteristics
  - Sinuosity
- Windshield survey

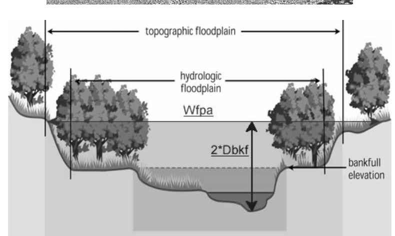
- Try to determine activities that are potentially impacting river process

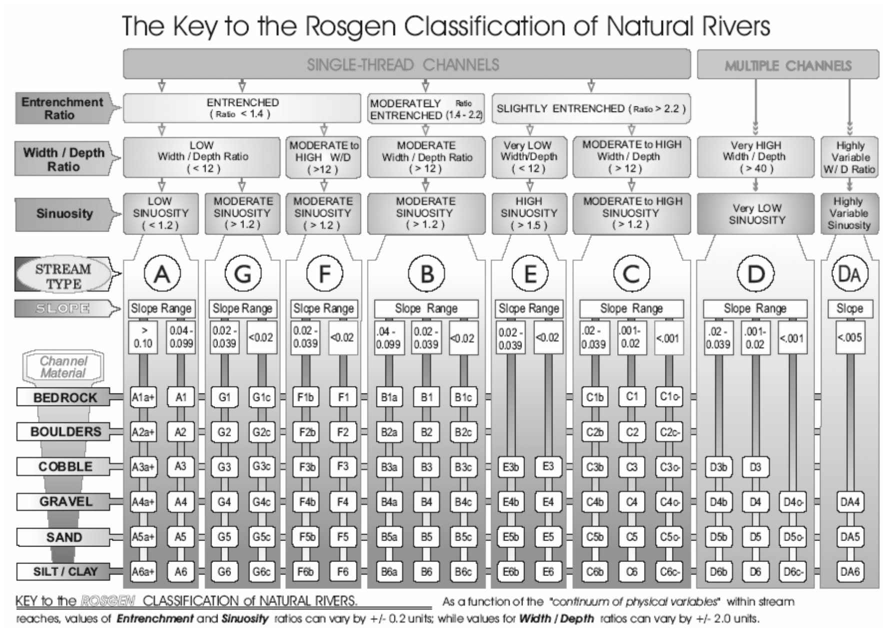


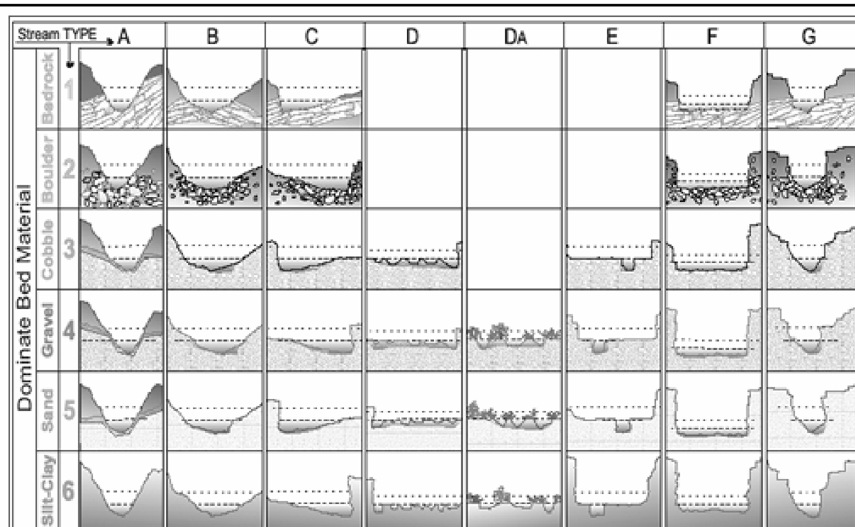
Phase 2

- In-depth field assessment. For each reach, we collect:
  - Stream channel dimensions (width, depth, floodprone width, bed material)
  - River corridor encroachments
  - Condition of the banks and adjacent floodplain
  - Wetlands, debris jams, stormwater inputs, beaver dams
  - Bed sediment storage, bars, headcuts, alterations (such as channel straightening)
  - Rapid habitat assessment
  - Rapid geomorphic assessment









Stream TYPE	A	B	C	D	DA	E	F	G
Entrchmnt	< 1.4	1.4 - 2.2	> 2.2	n/a	> 4.0	> 2.2	< 1.4	< 1.4
W/D Ratio	< 12	> 12	> 12	> 40	< 40	< 12	> 12	< 12
Sinuosity	1 - 1.2	> 1.2	> 1.2	n/a	variable	> 1.5	> 1.2	> 1.2
H_2O Slope	.04-.099	.02-.039	< .02	< .04	<.005	< .02	< .02	.02-.039

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Adjustment Process	Condition Category			
	Reference	**Good**	**Fair**	**Poor**
7.1 Channel Degradation (Incision) • Exposed till or fresh substrate in the stream bed and exposed infrastructure (bridge footings). • New terraces or recently abandoned flood prone areas. • Headcuts, or nickpoints significantly steeper bed segment and comprised of smaller bed material than typical steps. • Freshly eroded, vertical banks. • Alluvial sediments that are imbricated (stacked like dominoes) high in the bank. • Tributary rejuvenation, observed through the presence of nickpoints at or upstream of the mouth of a tributary. • Depositional features with steep faces, usually occurring on the downstream end. **Stream Type Departure** ☐ **Type of STD:**______________	☐ Little evidence of localized slope increase or nickpoints.	☐ Minor localized slope increase or nickpoints.	☐ Sharp change in slope, head cuts present, and/or tributaries rejuvenating.	☐ Sharp change in slope and / or multiple head cuts present. Tributaries rejuvenating.
	☐ Incision Ratio ≥ 1.0 < 1.2 **and** Where channel slope < 4% Entrenchment ratio > 1.4 Where channel slope ≥ 4% Entrenchment ratio > 1.2	☐ Incision Ratio ≥ 1.2 < 1.4 **and** Where channel slope < 4% Entrenchment ratio > 1.4 Where channel slope ≥ 4% Entrenchment ratio > 1.2	☐ Incision Ratio ≥ 1.4 < 2.0 **and** Where channel slope < 4% Entrenchment ratio > 1.4 Where channel slope ≥ 4% Entrenchment ratio > 1.2	☐ Incision ratio ≥ 2.0 **and** Where channel slope < 4% Entrenchment ratio ≤ 1.4 Where channel slope ≥ 4% Entrenchment ratio ≤ 1.2
	☐ Step-pool systems have full complement of expected bed features, steps complete with coarser sediment (≥ D80).	☐ Step-pool systems have full complement of expected bed features, steps mostly complete.	☐ Step-pool systems with incomplete (eroded) steps, dominated by runs.	☐ Step-pool bed features eroded and replaced by plane bed features.
	☐ No significant human-caused change in channel confinement.	☐ Only minor human-caused change in channel confinement.	☐ Significant human-caused change in channel confinement but no change in valley type.	☐ Human caused change in valley type.
	☐ No evidence of historic / present channel straightening, dredging, and/or channel avulsions.	☐ Evidence of minor historic dredging and/or channel avulsion.	☐ Evidence of significant historic channel straightening, dredging, or gravel mining, and/or channel avulsions.	☐ Extensive historic channel straightening, commercial gravel mining, and/or recent channel avulsions.
	☐ No known flow alterations (i.e., increases in flow and/or decreases in sediment supply).	☐ Some increase in flow and/or minor reduction of sediment load.	☐ Major historic flow alterations, greater flows and/or reduction of sediment load.	☐ Major existing flow alterations, greater flows and/or reduction of sediment load.
Score: **Historic** ☐	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

7.5 Channel Adjustment Scores – Stream Condition – Channel Evolution Stage

Condition Departure	Reference N/S	Good Minor	Fair Major	Poor Extreme	STD*	Historic	Condition Rating: (Total Score / 80)	Channel Evolution Stage:
Degradation								
Aggradation								
Widening							**7.6 Stream Condition:**	
Planform								
Sub-totals:					**Total Score:**			

Channel Adjustment Processes: ______________________________

7.7 Stream Sensitivity: Very Low / Low / Moderate / High / Very High / Extreme

*STD = Stream Type Departure where existing stream type is no longer the same as the reference stream type.

Stream Sensitivity

Decreasing quality of stream condition

Increasing instability by stream type

Existing Stream Type	In regime – Reference or good condition	Major Adjustment – Fair Condition	Stream Type Departure or Poor Condition
A1, A2, B1, B2	Very Low	Very Low	Low
C1, C2	Very Low	Low	Moderate
G1, G2	Low	Moderate	High
F1, F2	Low	Moderate	High
B3, B4, B5	Moderate	High	High
B3c,C3, E3	Moderate	High	High
C4, C5, B4c, B5c, E4, E5	High	Very High	Very High
A3, A4, A5, G3, F3,	High	Very High	Extreme
G4, G5, F4, F5	Very High	Very High	Extreme
D3, D4, D5	Extreme	Extreme	Extreme

So, let’s say a river reach rates as high, very high, or extreme in stream sensitivity?

Does that means the river reach fulfills geomorphic integrity, or a condition of stability?

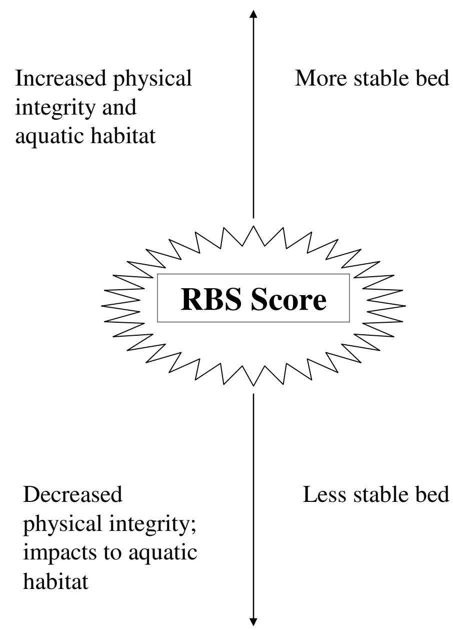
Well, that’s part of the story!

Provides a nice summary of channel stability risk

Let’s see what others have been doing to crack this nut

EPA
Relative Bed Stability Index

- Basic premise: For a reach of stream, are there more fine materials on the bed than one would expect?
- If so, it suggests, an upstream source – probably bank erosion (which means potential instability) somewhere upstream.
- Excess sediment has been leading cause of water quality impairment for years.



Bed stability ONLY!! Does not account for channel downcutting, or sediment accumulation

Arizona

- Arizona Department of Environmental Quality
- No geomorphic or physical habitat integrity definition in rules. Only mention in rules is with regard to “bottom sediments.”
- Hence, why chose RBS
- Showed promising results

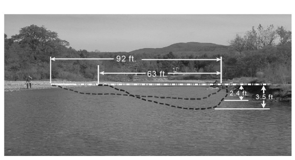
Vermont

- Is also considering adopting a legislative use definition for river physical integrity.
- Looking at options.
- Phase 2 output as “first cut”

Phase 3

Vermont Stream Geomorphic Assessment
Phase 3 Handbook

SURVEY ASSESSMENT



FIELD AND DATA ANALYSIS
PROTOCOLS

Vermont Agency of Natural Resources
May 2009

•A detailed, survey-grade field assessment that goes beyond a rapid Phase 2.

•The next step in trying to assess river instability?

•Link to instability?

•A combination with the EPA Relative Bed Stability index?

WARSSS
Watershed Assessment of River Stability & Sediment Supply

- EPA
- Three phases:
  - Reconnaissance Level Assessment (RLA)
  - Rapid Resource Inventory for Sediment and Stability Consequence (RRISSC)
  - Prediction Level Assessment (PLA)
- Similarities to Vermont Phase 1-3 protocols

Other Considerations

- Establishing a baseline for monitoring changes – permanent benchmarks
- Long-term monitoring

Summary

- We have a Phase 2 protocol presently in use that gives us some idea of a river's *potential sensitivity to future change*.
- But is it unstable, or lacking integrity?
- Phase 2 can tell us if a reach has potential instability, as a "first cut" for more measurements to determine true instability.